

**Evaluation of the 2014 Predictions of  
Run-size and Passage Distributions of  
Adult Chinook Salmon [*Oncorhynchus tshawytscha*]  
Returning to the Columbia and Snake Rivers**

Technical Report

Postseason Analysis  
January 2014 – December 2014

Prepared by:

W. Nicholas Beer  
Susannah Iltis  
James J. Anderson

Columbia Basin Research  
School of Aquatic and Fishery Sciences  
University of Washington  
Box 358218  
Seattle, WA 98195

Prepared for:

United States Department of Energy  
Bonneville Power Administration  
Division of Fish and Wildlife  
P.O. Box 3621  
Portland, OR 97208

Project No. 1989-108-00  
Contract No. 00066635

May 5, 2015

## Executive Summary

This report is a postseason analysis of the accuracy of the 2014 predictions from Escapement Forecaster / Adult Upstream Model. The effectiveness of these modeling efforts are compared to observations of passage and river conditions at the end of the season. A pattern matching routine forecasts total run-size and run timing (daily passage) by optimally correlating the shape of the current year's cumulative passage (to date) with truncations of historical cumulative passage data. At the end of the season, for each stock at each observation site, we compute the Mean Absolute Deviation (MAD) for the passage distributions which is a broad measure of the average error in daily passage percentage estimates. For spring and fall Chinook in 2014 it was 3.3% and 3.2% respectively. The maximum daily errors were 15.1% for both spring and fall fish.

## Table of Contents

|   |    |
|---|----|
| Executive Summary .....                         | i  |
| Table of Contents .....                         | i  |
| List of Figures .....                           | ii |
| List of Tables .....                            | ii |
| Introduction .....                              | 1  |
| Methods .....                                   | 1  |
| Data .....                                      | 1  |
| Models .....                                    | 2  |
| Postseason Assessment of Predictions .....      | 5  |
| Results .....                                   | 5  |
| Initial Run-size .....                          | 5  |
| Escapement Forecaster .....                     | 5  |
| Run Timing .....                                | 6  |
| Discussion .....                                | 6  |
| Results and Discussion Figures and Tables ..... | 7  |
| References .....                                | 14 |
| Appendix .....                                  | 16 |

## List of Figures

|  |    |
|--|----|
| Figure 1 Schematic of data, models and products. Brown is used for historical data, green is real time up-to-date information, white boxes are modeling processes and the yellow frames are final products. ....   | 4  |
| Figure 2 Passage of Chinook at BON in 2014 with calendar cutoff dates shown. Blue are the daily passage of adults and green (differently scaled) are the jacks. Black curves show idealized normal distributions of three runs. ....   | 7  |
| Figure 3 Changes in the daily run size prediction for spring Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of spring Chinook arrivals at Bonneville Dam. Note that the “predictions” are the day-to-day declarations of what percentage of the run has passed on this day. That is one reason it has “notches” in it. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix. .... | 11 |
| Figure 4 Changes in the daily run size prediction for fall Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of fall Chinook arrivals at Bonneville Dam (right). Note that the “predictions” are the day-to-day declarations of what percentage of the run has passed on this day. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix. ....  | 12 |
| Figure 5 Relationship of previous year Jack counts to spring Chinook adult returns (left). A prediction for 2014 was not available at the time of writing. Predicted vs. Observed abundance is shown on right. ....  | 13 |
| Figure 6 Relationship of previous year Jack counts to fall Chinook adult returns (left). Point 2014 is observed jacks for 2013 and a prediction of adults in 2014 based on an auto-regressive model using the previous year’s jack and adult counts. ....  | 14 |

## List of Tables

|   |    |
|---|----|
| Table 1 U.S. Army Corps of Engineers fixed monitoring sites and USGS gaging stations used for temperature forecasts. ....   | 2  |
| Table 2 Calibration parameters used for AUM runs since 2011. ....   | 4  |
| Table 4 Summary of Mean Absolute Deviation (MAD %) and Maximum Daily Deviation (MADD %) results for recent years (BON). ....  | 8  |
| Table 5 Earliest day in 2014, after which the final run-size prediction was within the error specified (10% 20%, or 30%) . In parentheses, corresponding dates for 2013, 2012, ... 2005 respectively. ....                    | 8  |
| Table 6 MAD values and MADD values (in parentheses) for other dams in 2014 and 2013. ....   | 9  |
| Table 7 In-house and Pacific Fishery Management Council 2014 preseason predictions and postseason results of BON and/or ocean escapement. Numbers in thousands of fish. ....  | 9  |
| Table 8 CBR adult preseason predictions (jack-adult regression) and postseason results for spring Chinook adult run size at Bonneville and fall Chinook run size at Bonneville, 2002-2014. Numbers in thousands of fish. .... | 10 |

## Introduction

Visual counts of returning adult Chinook have been made at Bonneville Dam each year since 1938. The detection of adult Chinook at Bonneville and upstream dams provides a measure of the temporal distribution of the returning adult salmonid populations.

The adult upstream "RealTime" forecaster/passage model was developed to predict the current season's adult salmon run-size at Bonneville Dam and run timing from the Bonneville Dam Tailrace to the upstream dams on the Columbia and Snake Rivers. The forecaster consists of an Escapement Forecaster (EF) that predicts the arrival timing and run-size of adult salmon at Bonneville Dam and an Adult Upstream Model (AUM) that predicts the passage timing of the fish at dams above Bonneville Dam. Each day the predictions are updated on the web.

During the 2001 migration season, Columbia Basin Research launched a prototype run timing system, EF/AUM, to predict run timing with results updated on the World Wide Web. This project was launched in an effort to provide real-time in-season projections of adult salmon migration to managers of the Columbia-Snake River hydrosystem to inform decisions about mitigation efforts such as in-river harvest. The program EF uses an empirical pattern matching routine to predict the arrival distributions for adult Chinook salmon stocks at the first detection point in the migratory route, Bonneville Dam. The AUM model takes the predictions from EF and uses hydrological, fish behavioral and dam geometry information to simulate the movement of the adult salmonid through mainstem Columbia and Snake River dams.

This report is a postseason analysis of the accuracy of the 2014 predictions from EF/AUM. Model results are compared to observations of passage and river conditions at the end of the season. We also compare key results to previous seasons.

## Methods

### *Data*

#### *Escapement and travel time data*

The fish analyzed in this report are adult spring and fall Chinook salmon returning to spawn in tributaries (or hatcheries) of the Columbia and Snake Rivers above Bonneville Dam. For the escapement forecasts, the daily visual counts of returning adult Chinook data come from Bonneville Dam. To assess our upstream run timing predictions, the daily visual counts come from additional detection sites at McNary and Lower Granite Dams. Data is retrieved from a link to the Columbia River DART database and provided as a courtesy by U.S. Army Corps of Engineers, NWD (<http://www.nwd.usace.army.mil>).

#### *Flow and other system operations data*

Any forecast of fish movement relies critically on accurate forecasts of flow, and other key system operations. The U.S. Army Corps of Engineers generates operational forecasts at all projects on the Columbia and Snake Rivers where there is fish passage. Water supply forecasts are based on a number of factors: the National Weather Service's Northwest River Forecast Center predictions, flood control requirements from the Army Corps, electrical power demand forecasts, and other criteria. The substantial uncertainty associated with springtime conditions often results in frequent and marked changes in these forecasts during April and May. Moreover, attempts to reduce the biological impacts of dissolved gas generated from high spill levels also results in a shifting of spill between projects within as well as outside the basin. Although the forecasts covered as much as 90 days into the future, it must be recognized that their intended use was in deciding operations for the next week. Forecast accuracy beyond even a few days was itself uncertain. On a monthly basis throughout the season, Bonneville Power Administration provides CBR staff with a long-term system operations forecast.

On a daily basis, forecasts for flow, spill, and elevation are replaced with observations with a query to the

Columbia River DART database (CBR 2014a), which includes water quality data from the Army Corps for the majority of monitoring sites in the Columbia Basin. Subsequent fish arrival predictions are therefore based on the forecasted values for flow and spill and the latest available observed data.

### *Temperature data*

The temperature time series is a combination of year-to-date temperature data and forecasted temperatures. The forecasts are based on observed year-to-date temperature and flow data, historical average temperature and flow profiles for 15 locations in the Snake and Columbia rivers, and the flow forecasts. Historic and observed year-to-date data was obtained from the Columbia River DART database. Temperature predictions are made by applying a three-day moving window to fit predicted temperature time series to historical average patterns of temperature change; this method is described in detail in Beer et al. (2004).

**Table 1 U.S. Army Corps of Engineers fixed monitoring sites and USGS gaging stations used for temperature forecasts.**

| Monitoring Locations     | AUM Model Input Locations        |
|--------------------------|----------------------------------|
| Chief Joseph Forebay     | Columbia Headwater               |
| Wells Forebay            | Methow Headwater                 |
| Rock Island Forebay      | Wenatchee Headwater              |
| The Dalles Forebay       | Deschutes Headwater              |
| Anatone, WA USGS         | Snake Headwater                  |
| Peck, ID USGS            | Clearwater Headwater             |
| Peck, ID USGS            | North Fork Clearwater Headwater  |
| Peck, ID USGS            | Middle Fork Clearwater Headwater |
| Anatone, WA USGS         | Salmon Headwater                 |
| Wells Forebay            | Wells Pool                       |
| Rocky Reach Forebay      | Rocky Reach Pool                 |
| Rock Island Forebay      | Rock Island Pool                 |
| Wanapum Forebay          | Wanapum Pool                     |
| Priest Rapids Forebay    | Priest Rapids Pool               |
| Lower Granite Forebay    | Lower Granite Pool               |
| Little Goose Forebay     | Little Goose Pool                |
| Lower Monumental Forebay | Lower Monumental Pool            |
| Ice Harbor Forebay       | Ice Harbor Pool                  |
| McNary Forebay           | McNary Pool                      |
| John Day Forebay         | John Day Pool                    |
| The Dalles Forebay       | The Dalles Pool                  |
| Bonneville Forebay       | Bonneville Pool                  |

### *Archives of model predictions*

The results of EF/AUM runs are stored on the Columbia Basin Research web site (CBR 2014b). Graphs based on the results are available through web-based query tools at [http://www.cbr.washington.edu/crisprt/index\\_adult.html](http://www.cbr.washington.edu/crisprt/index_adult.html). Runs are made daily and include daily passage distribution forecasts and run-size forecasts.

### *Models*

#### *Initial Run size*

The year's initial run-size is determined from a linear regression of each year's adult return vs. the previous year's jack return and environmental conditions. The timeframe for the spring run at Bonneville

is March 15 to June 15 and the timeframe for the fall run is August 1 to November 15. The spring run was predicted as 236,000 and the fall run as 396,000.

### *Escapement Forecaster*

The Escapement Forecaster predicts the arrival timing and run-size of adult salmon at Bonneville Dam. It consists of an expected distribution based on the previous year's jack counts in the early season, and switches to a pattern matching algorithm as the season progresses. There is also a blending routine to switch smoothly between the jack-based and pattern match methods.

The arrival distribution is taken as the historic daily mean scaled to produce the correct total run-size. The pattern matching routine forecasts total run-size and run timing (daily passage) by optimally correlating the shape of the current year's cumulative passage (to date) with truncations of historical cumulative passage data. This returns the fraction of the run complete,  $f$ . Total run-size is then predicted by  $\tilde{r} = P_c / f$  where  $P_c$  is the total passage (current year) to date.

To compare the current year's passage to that of historic runs, the cumulative current passage data is partitioned into  $N$  time intervals. The pattern matching optimization is performed as least-squares minimization; comparing slopes  $S_i^c$  over each subinterval  $i$  of the current run with slopes  $S_i^h(f)$  of subintervals of each historic year run truncated after  $f$  fraction of the historic run has passed. The optimization to determine  $f$  is then performed as:

$$\text{minimize}_{f \in (0,1)} \sum_{h \in H} \sum_{i=1}^N (S_i^c - S_i^h(f))^2$$

where  $H$  is the set of historical data years being used.

After the pattern matching method determines the completed fraction  $f$  of the current run, the passage forecast for each remaining day of the season is produced by appending the historic daily mean passage for each day of the final  $1 - f$  fraction of the season, scaled to produce the correct total run-size. In this way, the forecast may be a forward or backward shift in time as compared to the historic average, thereby forecasting not just run-size, but also run timing.

### *Adult Upstream Model*

The Adult Upstream Model (AUM) describes in detail fish movement through reaches and dams and the effects of various river operations on their migration. For in-season forecasts, we use the projected escapement at Bonneville as input to AUM and predict the arrival timing at the upstream dams. The model contains a temperature and flow based submodel for reservoir passage and submodels for dam passage, fallback and straying. In addition, it includes a bioenergetic model to predict fish migration energy consumption. River flow and temperature are modeled using portions of the COMPASS smolt passage model. Fish travel time has been calibrated using PIT-tag data of adult Chinook detected at multiple dams following the method of Salinger and Anderson (2006). The temperature and flows encountered by upstream migrating salmon are the main factors determining reach migration speed and a submodel controls this process. The flow encountered should subtract directly from the swimming speed in order to compute net up-river velocity. Because oxygen metabolism of Chinook is optimal at about 17°C, the sustainable swimming speed is also optimal at about 17°C. To represent this, we use a broken linear model for the net up-river velocity  $V_M$  in terms of temperature  $\theta$  and flow  $F$ :

$$V_M = \begin{cases} \beta_0 + \beta_1\theta + \beta_3F, & \text{where } \theta \leq \tilde{\theta} \\ \beta_0 + \beta_1\tilde{\theta} + \beta_2(\theta - \tilde{\theta}) + \beta_3F, & \text{where } \theta > \tilde{\theta} \end{cases}$$

where  $\beta_0$ ,  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  are the coefficients and  $\tilde{\theta}$  is the break point (approximately 17°C). In each reach, the travel time distribution is determined by the migration velocity  $V_M$  and by the rate of spreading  $V_{VAR}$  (Zabel and Anderson, 1997). Salinger and Anderson (2006) more fully develops the net up-river velocity submodel. The migration velocity parameters and the spread parameter ( $V_{VAR}$ ) are determined from historical data using an optimization routine that compares model predicted passage distributions to observed ones. The arrival distributions were constructed from PIT-tag data of fish detected at lower and upper dams. These are combined into weekly cohorts with known travel time median and standard deviation. The cohorts create a *release* distribution at Bonneville Dam, and the model results are compared to the observations using least-squares optimization to pick the best parameterization of the model. Fall-back and dam delay are components contributing to the distribution of travel times for the fish.

The travel time parameters used for modeling passage in 2013 are shown in Table 2.

**Table 2 Calibration parameters used for AUM runs since 2011.**

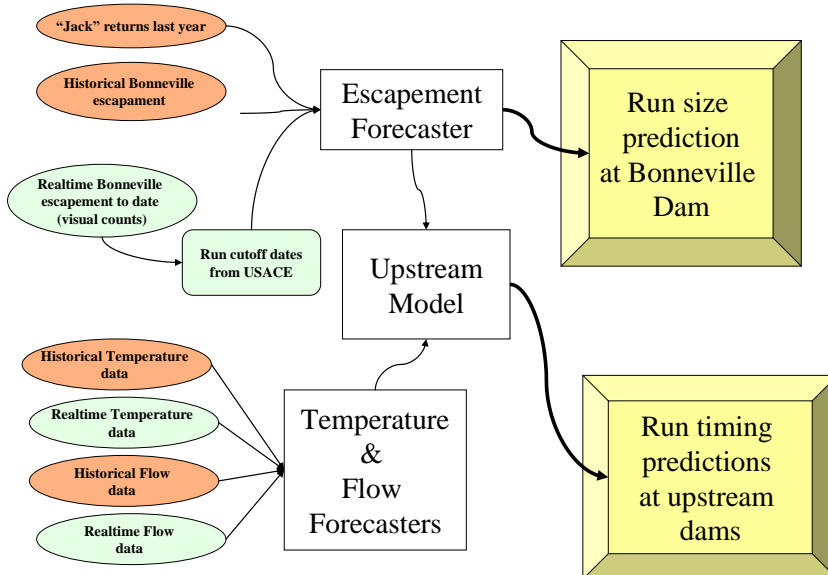
| Stock        | Years     | b0       | bTemp   | bFlow   | vVar      | R <sup>2</sup><br>(Model vs.Obs.) |
|--------------|-----------|----------|---------|---------|-----------|-----------------------------------|
| Snake Spring | 2001-2010 | -47.0946 | -1.5702 | 12.5731 | 92.7221   | 0.81                              |
| Snake Fall   | 2001-2010 | -11.7618 | -4.7013 | 8.8822  | 221.1399  | 0.86                              |
| UC Spring    | 2002-2010 | 41.9984  | -1.0080 | 1.7434  | 28.6857   | 0.81                              |
| UC Fall      | 2003-2010 | -9.2297  | 1.8737  | 2.7201  | 2391.0635 | 0.9                               |
| Yakima (All) | 2002-2010 | -12.8538 | -2.4660 | 9.6807  | 87.7347   | 0.43                              |

<sup>a</sup>The parameters for Upper Columbia Fall are also applied to Lower Columbia Fall stocks.

<sup>b</sup>The parameters for Snake Spring are also applied to Lower Columbia Spring stocks.

### *Schematic of data and modeling*

The relationship of the data and models is depicted in Figure 1.



**Figure 1 Schematic of data, models and products. Brown is used for historical data, green is real time up-to-date information, white boxes are modeling processes and the yellow frames are final products.**

## Postseason Assessment of Predictions

### Mean Absolute Deviation

To assess the performance of run-size predictions, we compute the first day when the run-size estimate was within 10, 20 and 30% of the true run-size, and we determine what percent of the run had been completed on that day. Run size predictions are important for catch allocations, and compliance with federal and state regulations on fishery management. There is no established standard by which these predictions are evaluated.

To assess the performance of passage timing predictions, we apply the same measure used to assess RealTime/COMPASS predictions (Beer et al. 2008). For each stock at each observation site, we compute the Mean Absolute Deviation (MAD) for the day ( $j$ ) on which the prediction was made. This measure is based on the average deviation between predicted and observed cumulative passage on prediction dates during the season. MAD is computed as:

$$MAD_j = \frac{1}{N} \sum_{t=1}^N \left| F_{Day_t} - \hat{F}_{Day_{ij}} \right| \times 100$$

where:

$j$  = forecast day on which  $MAD_j$  is calculated;

$t$  = index of prediction day (from 1 to  $N$ );

$N$  = number of days on which a prediction and observation were made for the stock at the site during the season;

$Day$  = vector of length  $N$  which identifies the days of the year from first observation of the stock at the site until two weeks past last observation (this is fixed for each site and each stock);

$F$  = observed cumulative passage on  $Day_t$ ; and

$\hat{F}$  = predicted cumulative passage on  $Day_t$ .

The MAD summation is performed over each of the dates on which model predictions were implemented – approximately every day during the season. This provides a snapshot of how well the model performs as the season progresses based on the final, “true” data. Ideally, there would be general decrease in MAD as  $t$  goes from 1 to  $N$  because the true distribution of the run should be better known and the true state of the flow and spill profiles should be known.

A second measure for run timing is the Maximum Absolute Daily Deviation (MADD)

$$MADD = \max \left\{ \left| F_{Day_t} - \hat{F}_{Day_t} \right| \times 100 \right\}$$

All estimates of the run passage percentage are as good or better than this estimate.

## Results

### Initial Run-size

The preseason estimates for the spring run were every close, while the fall abundance doubled the preseason prediction (see Table 6).

### Escapement Forecaster

The escapement forecaster predicted within 20% of the final spring run size on day 127 (May 7). The range is from day 87 to 134. The fall prediction is much more stable as always (day 251, Sept. 8, range 234 to 255). The predicted daily passage percentile time series and observed distribution are shown in Figure 3 and Figure 4.



Daily predictions for 2014 can be viewed from the Forecast Archive web page, at <http://www.cbr.washington.edu/crisprt/archive.html>. Alternative targets (10%, 20% and 30%) were each evaluated and are summarized in Table 4.

### *Run Timing*

The EF/AUM model is run daily and upstream passage predictions are archived. Predictions are compared to observations of passage at the end of the migration season. See the figures in the Appendix for passage predictions on several days and the end-of-year observations.

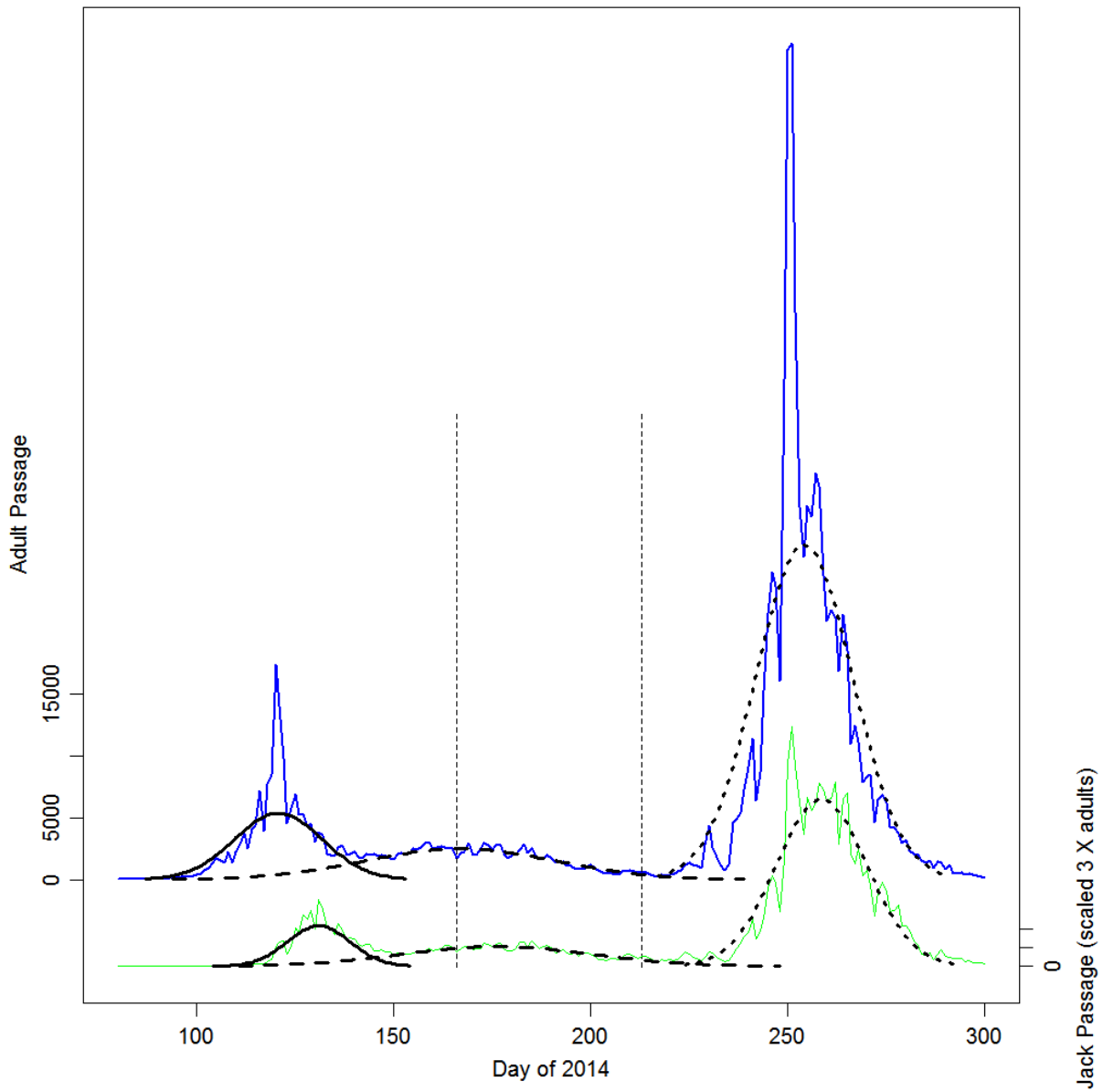
We track the success of these predictions by comparing the estimated percentage passed on each day with the observed passage percentage. For the spring run at Bonneville, the Mean Absolute Deviation (MAD) was 3.3%. The worst daily prediction, the maximum absolute daily deviation (MADD) was 15.1% on day 114 (Apr 24). Analogous metrics for the fall run are MAD = 3.2% and MADD = 15.1% on day 243. These results and others since 2003 are summarized in Table 4.

### *Discussion*

Predictions of passage at Bonneville shape the forecasts of passage at other dams, so all the predictions are sensitive to these important first observations. Any errors end up affecting upstream passage predictions, and run-size predictions interact with the passage percentage predictions. One measure of this error, the Maximum Absolute Daily Deviation (MADD), was 15.1% for both the spring and fall Chinook.

In early 2014, Pacific Fishery Management Council (PFMC 2014) issued a preseason forecast of ocean escapement for various stocks. Their predictions are a significant forecast that is used by various agencies for fishery management purposes. Although their predictions are different —ocean escapements not dam arrivals— the overall numbers are an index of the escapement that could be expected in the river. We always expect Bonneville passage to be less than the ocean escapement due to turnoffs and harvest. The PFMC Fall Chinook are divided into 5 distinct stocks. Three of them (MCB, URB and SCH) pass Bonneville Dam (and are enumerated as the fall run) and the other two are lower river stocks. Subsequent referrals to the PFMC predictions of fall Chinook will ignore the lower river fish. There is also a Spring Chinook and Summer Chinook prediction. Highlights of their predictions (PFMC 2014) and postseason analysis (PFMC 2015) are shown in Table 6. There are no other estimates of stock run-size for Chinook entering the Columbia.

The fall run is easier to model than the spring run, especially when run size is well predicted, because the timing is much more consistent than the spring run. The jack/adult relationship is shown in Figure 6. For fall Chinook at upstream dams, the final destinations are not certain for any fish arriving on any given day, so a relatively small runs like fall Chinook passing WEL or heading to the Yakima are not a symmetrical part of the larger fall run. The stock separation algorithm that routes fish to upstream locations in AUM is dependent on the expected distribution to upstream locations based solely on the previous year's distributions and the timing of the current run relative to the previous year. The best available stock separation fractions are determined daily according to the methods of Beer (2008).



**Figure 2** Passage of Chinook at BON in 2014 with calendar cutoff dates shown. Blue are the daily passage of adults and green (differently scaled) are the jacks. Black curves show idealized normal distributions of three runs.

**Table 3 Summary of Mean Absolute Deviation (MAD %) and Maximum Daily Deviation (MADD %) results for recent years (BON).**

| Measure      | Year | Spring Chinook | Fall Chinook |
|--------------|------|----------------|--------------|
| MAD %        | 2014 | 3.3            | 3.2          |
|              | 2013 | 7.7            | 3.8          |
|              | 2012 | 3.9            | 1.6          |
|              | 2011 | 1.9            | 3.4          |
|              | 2010 | 1.2            | 2.5          |
|              | 2009 | 7.0            | 2.6          |
|              | 2008 | 5.7            | 2.2          |
|              | 2007 | 2.6            | 4.7          |
|              | 2006 | 9.5            | 5.7          |
|              | 2005 | 3.9            | 3.0          |
|              | 2004 | 3.7            | 4.8          |
|              | 2003 | 6.7            | 3.9          |
| MADD % (day) | 2014 | 15.1 (114)     | 15.1 (243)   |
|              | 2013 | 19.3 (115)     | 10.8 (249)   |
|              | 2012 | 27.1 (126)     | 9.3 (256)    |
|              | 2011 | 7.2 (134)      | 14.5 (244)   |
|              | 2010 | 6.6 (107)      | 14.1 (266)   |
|              | 2009 | 20.0 (118)     | 13.8 (246)   |
|              | 2008 | 30.4 (118)     | 10.5 (248)   |
|              | 2007 | 11.2 (114)     | 17.1 (261)   |
|              | 2006 | 43.8 (121)     | 20.1 (261)   |
|              | 2005 | 25.0 (121)     | 17.7 (244)   |
|              | 2004 | 16.4 (114)     | 14.2 (254)   |
|              | 2003 | 18.4 (103)     | 19.3 (253)   |

**Table 4 Earliest day in 2014, after which the final run-size prediction was within the error specified (10% 20%, or 30%) . In parentheses, corresponding dates for 2013, 2012, ... 2005 respectively.**

| Stock  | Within 10%  | Within 20%  | Within 30%  |
|--------|---|---|---|
| Spring | <b>128</b><br>(157,133,126,118, 147,<br>140, 149, 161, 126) | <b>127</b><br>(120,132,87,109, 129, 126,<br>128, 134, 126)  | <b>119</b><br>(119,131,87,109, 126, 125,<br>117, 133, 127)  |
| Fall   | <b>258</b><br>(252,259,263,268, 264,<br>243, 267, 269, 249) | <b>251</b><br>(251,246,248,252, 247,<br>234, 243, 255, 250) | <b>250</b><br>(242,245,248,243, 218,<br>215, 243, 247, 251) |

**Table 5 MAD values and MADD values (in parentheses) for other dams in 2014 and 2013**

| Site | Spring<br>2014 | Fall<br>2014 | Spring<br>2013 | Fall<br>2013 |
|------|----------------|--------------|----------------|--------------|
| TDA  | 3.8 (12.5)     | 3.5 (12.8)   | 9.5 (19.4)     | 6.3 (16)     |
| JDA  | 3.7 (10.7)     | 2.9 (10.6)   | 9.5 (21.6)     | 7.4 (18.1)   |
| MCN  | 3.6 (20.6)     | 2.2 (9.0)    | 7.2 (19.7)     | 8.2 (20.4)   |
| IHR  | 6.5 (26.4)     | 2.4 (11.4)   | 6.0 (23.7)     | 4.9 (14)     |
| LMN  | 6.4 (24.8)     | 3.7 (17.3)   | 5.3 (20.8)     | 5.1 (13.4)   |
| LGS  | 6.7 (22.2)     | 3.2 (15.6)   | 5.2 (17.8)     | 3.8 (10.8)   |
| LWG  | 6.5 (20.8)     | 1.8 (10.3)   | 5.5 (19.6)     | 2.7 (7.5)    |
| PRD  | 7.5 (24.4)     | 4.1 (13.2)   | 9.6 (32.4)     | 7.0 (14.7)   |
| WEL  | 10 (45.8)      | 8.7 (30)     | 9.4 (40.6)     | 2.0 (19.9)   |

**Table 6 In-house and Pacific Fishery Management Council 2014 preseason predictions and postseason results of BON and/or ocean escapement. Numbers in thousands of fish.**

| Stock                                   | Pre-season         | Post-season<br>Inriver estimate | Bonneville<br>Passage <sup>d</sup> | Pre/<br>Postseason <sup>a</sup> | Source   |
|---|--------------------|---------------------------------|------------------------------------|---------------------------------|----------|
| BON Spring                              | 236                | 242                             | 224                                | 1.05                            | CBR/NOAA |
| BON Fall                                | 396                | -                               | 854                                | 0.46                            | CBR/DART |
| Upriver Spring<br>Chinook               |                    | 242 <sup>c</sup>                | 225 <sup>c</sup>                   | 1.1                             | PFMC     |
| Upriver Summer<br>Chinook               |                    | 78.3 <sup>c</sup>               | 72.8 <sup>c</sup>                  | 1.1                             | PFMC     |
| Fall Chinook (sum of<br>3 stocks below) | 1148.5             | 1309.8                          | 1166                               | 1.2                             | PFMC     |
| Spring Creek<br>Hatchery (SCH)          | 115.1              | 98.8 <sup>c</sup>               | 81 <sup>c</sup>                    | 1.4                             | PFMC     |
| Upriver Brights<br>(URB)                | 973.3 <sup>b</sup> | 860 <sup>c</sup>                | 830 <sup>c</sup>                   | 1.1                             | PFMC     |
| Mid-Columbia<br>Brights (MCB)           | 360.1 <sup>b</sup> | 351 <sup>c</sup>                | 255 <sup>c</sup>                   | 1.4                             | PFMC     |

Notes: Numbers quoted in this table are subject to change. Data for the PFMC predictions and assessment come from various documents including:

<sup>a</sup> The ratio is computed with Bonneville passage for the in-house BON or NOAA predictions and for the in-river estimate with the PFMC Preseason ocean abundance.

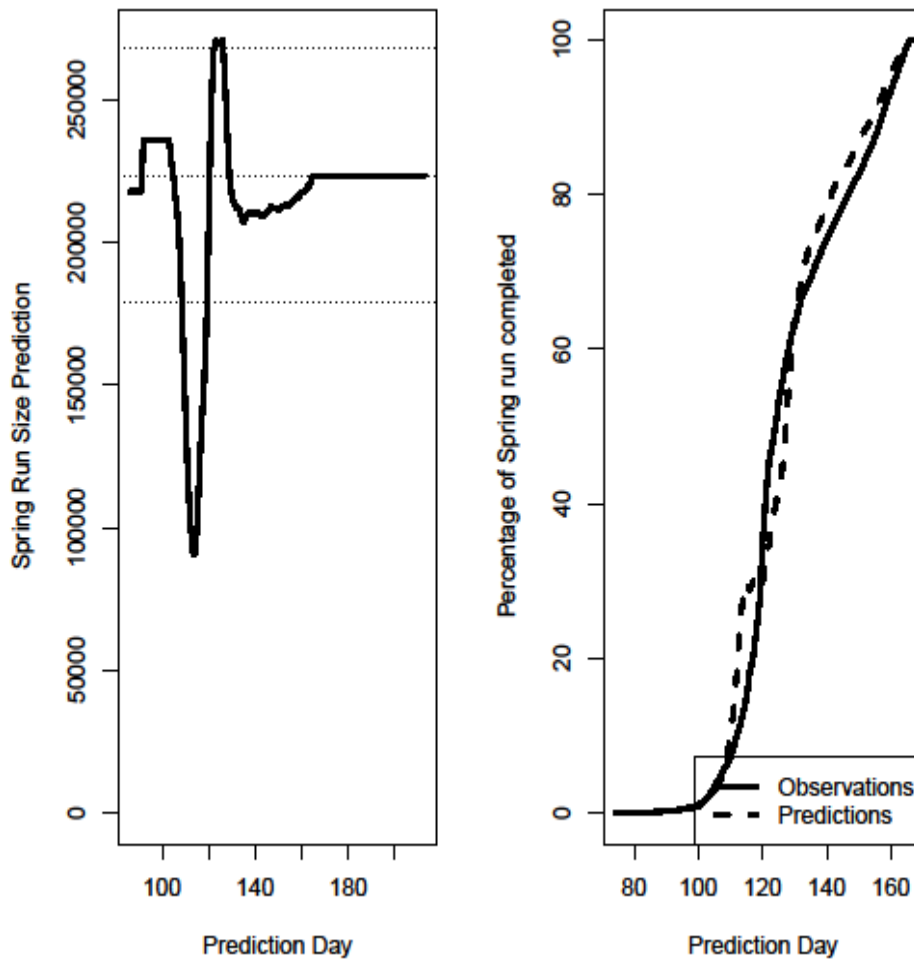
<sup>b</sup> The ocean escapement estimates from a pre-season forecast for 2014 Table I-1 (PFMC Feb 2014).

<sup>c</sup> A summary of previous years including 2014 is in the post-season document, Tables B-13 : B-19 (PFMC February 2015). These numbers are subject to change.

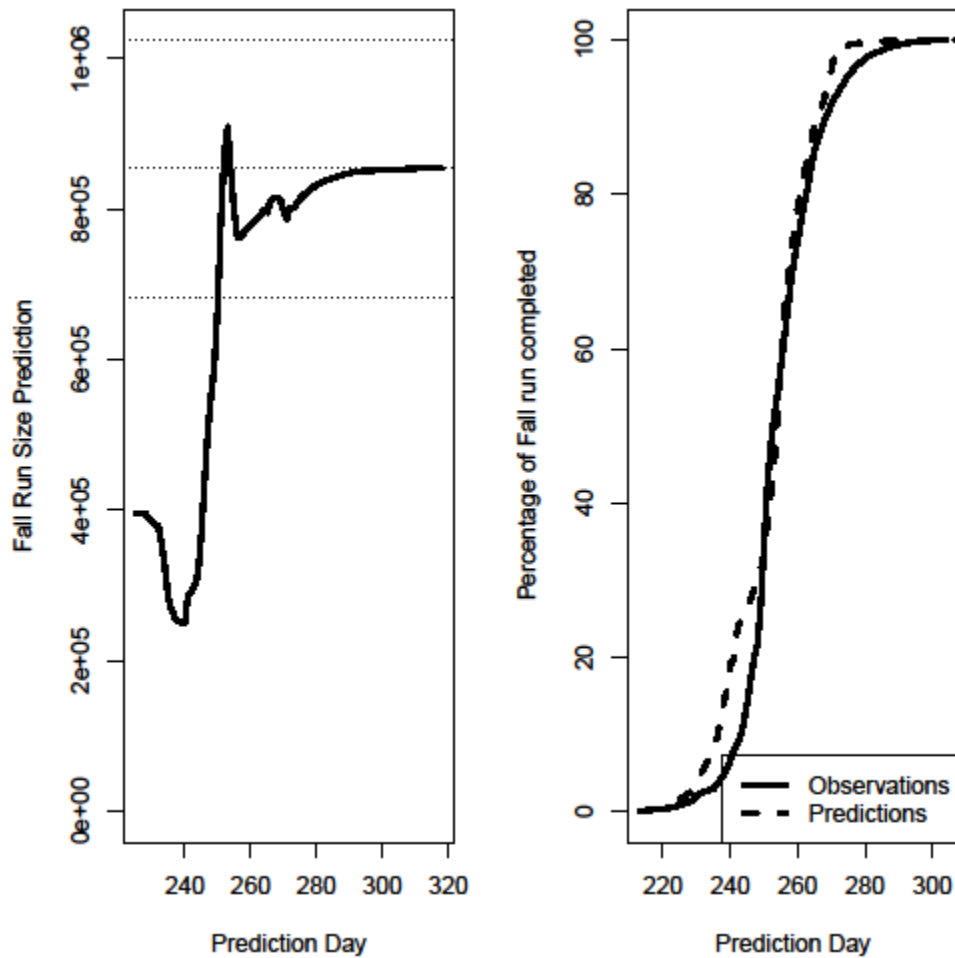
<sup>d</sup> Bonneville passage of a stock is determined by date alone. Springs: Mar 15 – June 15. Summers: June 16 – July 31. Falls: Aug. 1 – Nov. 15. Beginning in 2005, CBR adopted the June 15 end date for our spring Chinook run size forecast to best match the Columbia River Fisheries (CRM) spring management period. It is intended partially at least to include Snake River-bound spring Chinook.

**Table 7 CBR adult preseason predictions (jack-adult regression) and postseason results for spring Chinook adult run size at Bonneville and fall Chinook run size at Bonneville, 2002-2014. Numbers in thousands of fish.**

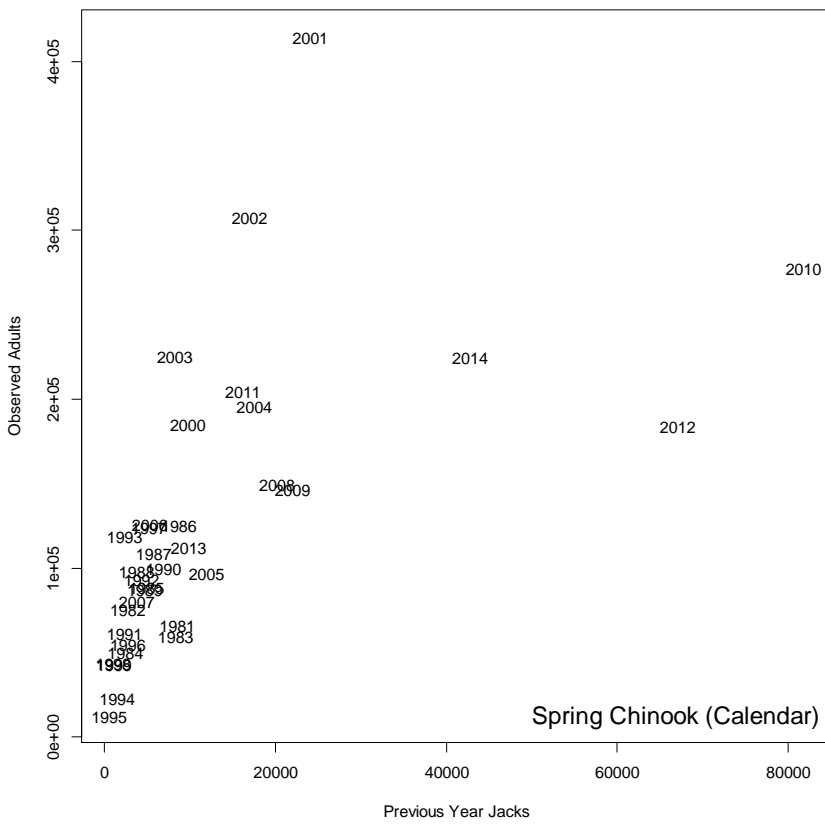
| Stock          | Year | Run Dates | Preseason<br>Forecast | Bonneville<br>Passage<br>Observed | Preseason/<br>Bonneville<br>Passage |
|----------------|------|-----------|-----------------------|-----------------------------------|-------------------------------------|
| Spring Chinook | 2014 | 3/15-6/15 | 236                   | 224                               | 1.05                                |
|                | 2013 | 3/15-6/15 | 218                   | 108                               | 2.0                                 |
|                | 2012 | 3/15-6/15 | 591                   | 185.1                             | 3.2                                 |
|                | 2011 | 3/15-6/15 | 209                   | 203.1                             | 1.0                                 |
|                | 2010 | 3/15-6/15 | 424.4                 | 277.3                             | 1.5                                 |
|                | 2009 | 3/15-6/15 | 294.3                 | 147.5                             | 2.1                                 |
|                | 2008 | 3/15-6/15 | 307                   | 150.1                             | 2.0                                 |
|                | 2007 | 3/15-6/15 | 83.1                  | 80.8                              | 1.0                                 |
|                | 2006 | 3/15-6/15 | 106.7                 | 126.2                             | 0.8                                 |
|                | 2005 | 3/15-6/15 | 212.4                 | 97.4                              | 2.2                                 |
|                | 2004 | 3/15-5/31 | 245.4                 | 168.7                             | 1.5                                 |
|                | 2003 | 3/1-5/31  | 121.4                 | 192.0                             | 0.6                                 |
|                | 2002 | 3/1-5/31  | 244                   | 268.8                             | 0.9                                 |
| Fall Chinook   | 2014 | 8/1-11/15 | 396                   | 854                               | 0.46                                |
|                | 2013 | 8/1-11/15 | 396                   | 890                               | 0.45                                |
|                | 2012 | 8/1-11/15 | 399.4                 | 350.2                             | 1.1                                 |
|                | 2011 | 8/1-11/15 | 272.4                 | 400.2                             | 0.7                                 |
|                | 2010 | 8/1-11/15 | 230.4                 | 467.8                             | 0.49                                |
|                | 2009 | 8/1-11/15 | 249.4                 | 283.4                             | 0.88                                |
|                | 2008 | 8/1-11/15 | 253.8                 | 315.3                             | 0.8                                 |
|                | 2007 | 8/1-11/15 | 231.2                 | 157.8                             | 1.5                                 |
|                | 2006 | 8/1-11/15 | 228.5                 | 299.2                             | 0.8                                 |
|                | 2005 | 8/1-11/15 | 239.0                 | 415.7                             | 0.6                                 |
|                | 2004 | 8/1-11/15 | 237.2                 | 583.7                             | 0.4                                 |
|                | 2003 | 8/1-11/15 | 218.1                 | 610.1                             | 0.4                                 |
|                | 2002 | 8/1-11/15 | 305.4                 | 473.8                             | 0.6                                 |



**Figure 3** Changes in the daily run size prediction for spring Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of spring Chinook arrivals at Bonneville Dam. Note that the “predictions” are the day-to-day declarations of what percentage of the run has passed on this day. That is one reason it has “notches” in it. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix.

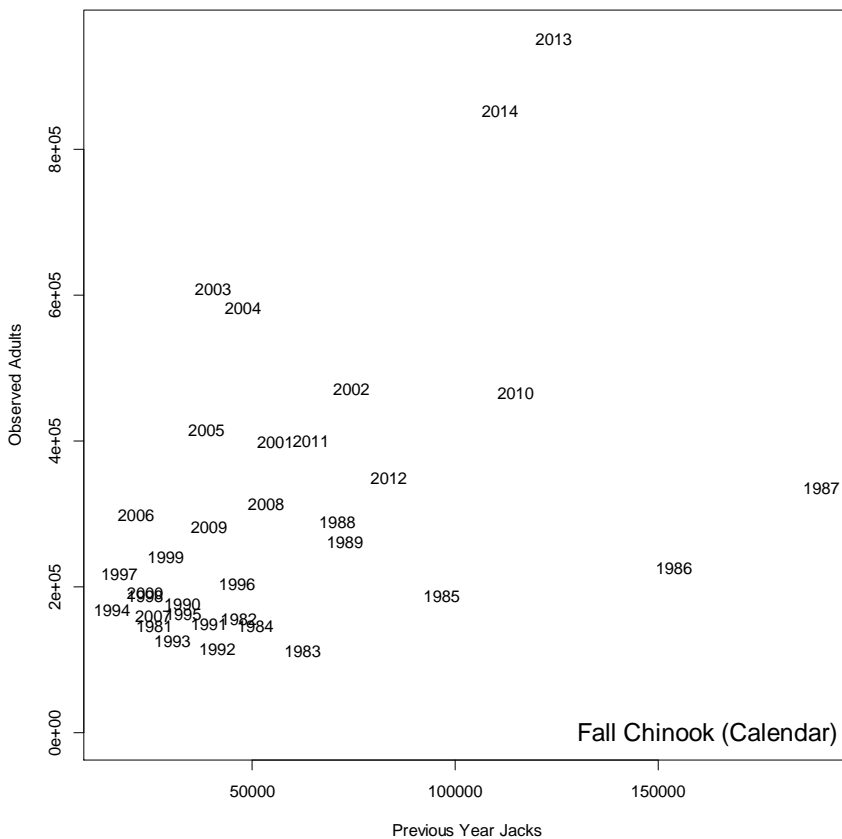


**Figure 4** Changes in the daily run size prediction for fall Chinook at Bonneville Dam. Horizontal bands depict 20% margin more or less than the final run size (left). Distribution of fall Chinook arrivals at Bonneville Dam (right). Note that the “predictions” are the day-to-day declarations of what percentage of the run has passed on this day. This is not the same as a comparison of observed passage versus modeled passage. For those, see Appendix.



**Figure 5 Relationship of previous year Jack counts to spring Chinook adult returns.**





**Figure 6 Relationship of previous year Jack counts to fall Chinook adult returns.**

## References

- Beer, W.N., S. Iltis, C. Van Holmes, and J.J. Anderson. 2004. Evaluation of the 2003 Predictions of the Run-Timing of Wild Migrant Yearling Chinook and Water Quality at Multiple Locations on the Snake and Columbia Rivers using CRiSP/RealTime. Columbia Basin Research, School of Aquatic and Fishery Sciences. University of Washington, Box 358218 Seattle, WA 98195.
- Beer, W.N. 2008. Stock Separation of Chinook salmon at Bonneville Dam for Adult Upstream Migration Model (2008). White Paper. Columbia Basin Research, School of Aquatic and Fishery Sciences. University of Washington, Box 358218 Seattle, WA 98195. Available March 31 at: <http://www.cbr.washington.edu/papers/StockSeparationforAUM2008.html>
- Columbia Basin Research (CBR). 2015a. Data Access in Real Time (DART) Available on-line 4 May 2015 at <http://www.cbr.washington.edu/dart/>.
- Columbia Basin Research (CBR). 2015b. Adult Passage Predictions based on Visual Counts for Combined Columbia and Snake River Stocks. Available on-line 4 May 2015 at [http://www.cbr.washington.edu/crisprt/index\\_adult.html](http://www.cbr.washington.edu/crisprt/index_adult.html)
- National Marine Fisheries Service (NMFS). 2013. Forecast of Adult Returns for coho and Chinook salmon

<http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm>

PFMC (Pacific Fishery Management Council) 2015. Preseason Report I. Stock Abundance Analysis and Environmental Assessment for 2014 Ocean Salmon Fisheries: Chapter II - Chinook Salmon Assessment. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220-1384. Available on-line 04 May 2015 at [http://www.pfcouncil.org/wp-content/uploads/Preseason\\_Report\\_I\\_2014\\_FINAL.pdf](http://www.pfcouncil.org/wp-content/uploads/Preseason_Report_I_2014_FINAL.pdf)

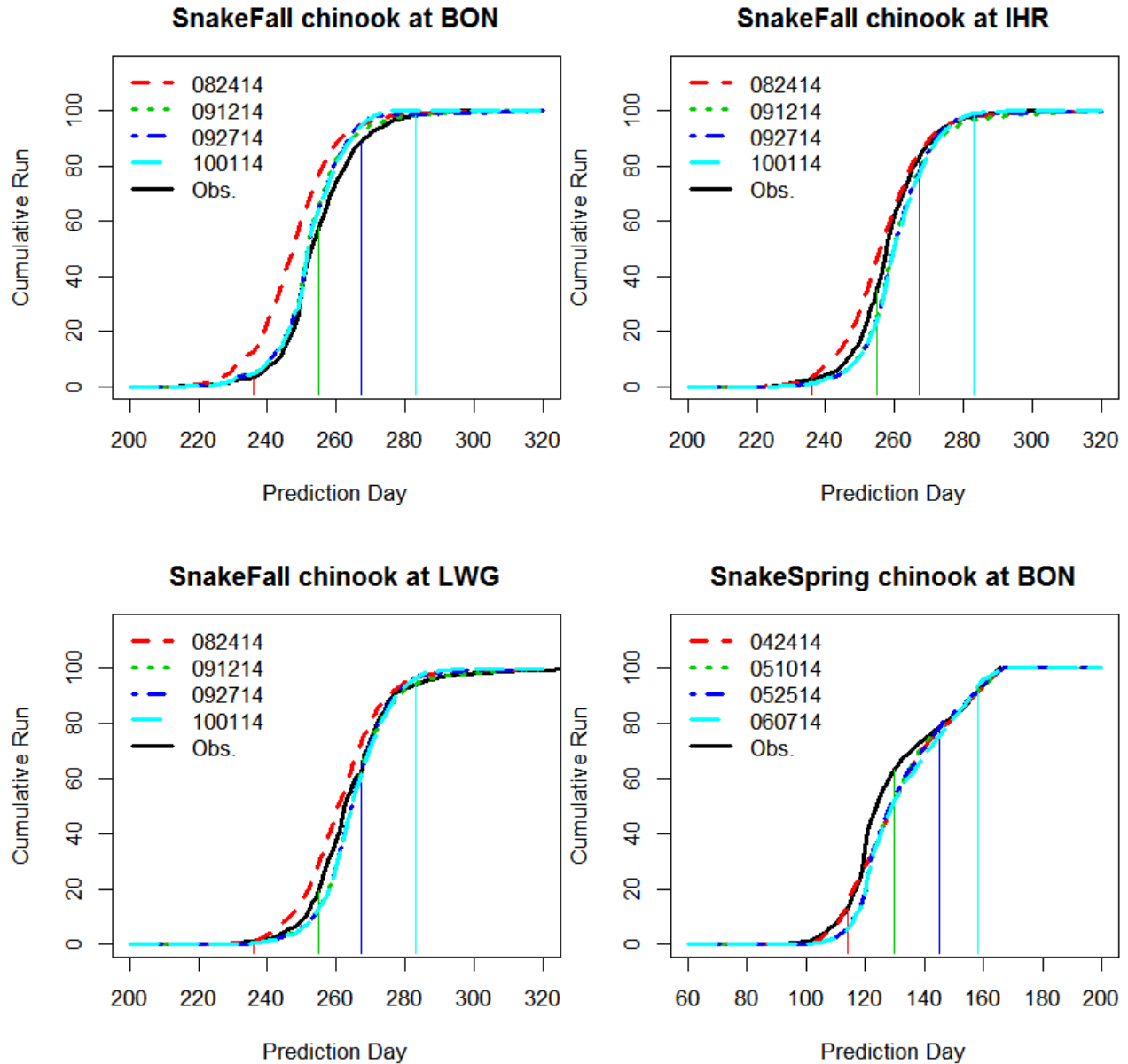
PFMC (Pacific Fishery Management Council) 2014. Review of 2014 Ocean Salmon Fisheries. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220-1384. Available On-line 4 May 2015 at [http://www.pfcouncil.org/wp-content/uploads/salsafe2014\\_FullDocument.pdf](http://www.pfcouncil.org/wp-content/uploads/salsafe2014_FullDocument.pdf)

Salinger, D.H. and J.J. Anderson. 2006. Effects of water temperature and flow on adult salmon migration swim speed and delay. *Transactions of the American Fisheries Society* 135:188-199.

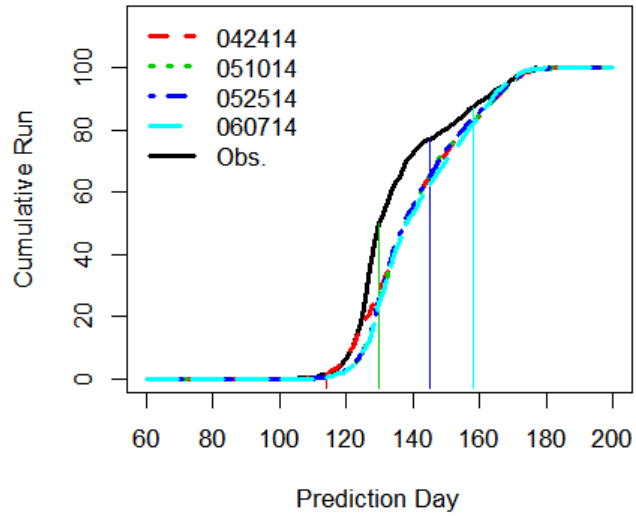
Zabel, R. and J.J. Anderson. 1997. A model of the travel time of migrating juvenile salmon, with an application to Snake River Spring Chinook. *N. Amer. J. Fish. Manag.* 17:93-100.

## Appendix

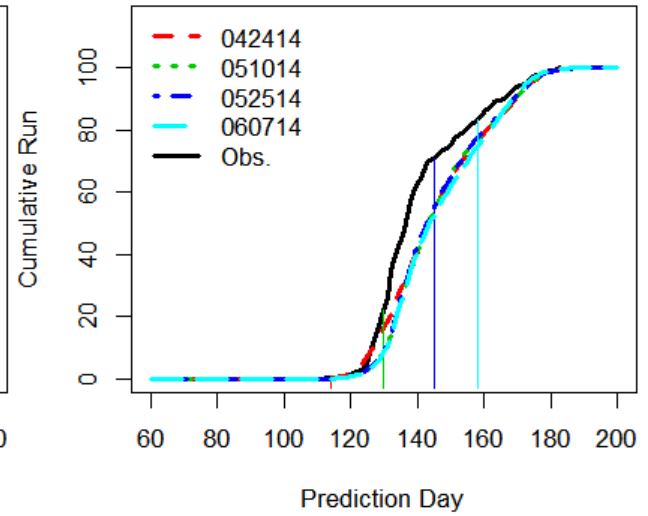
Predictions and observations of cumulative passage at multiple locations. The displays in this appendix depict the distribution of the run and its predictions through the seasons. Interpretation notes: A smooth, “normal-distribution” curve indicates that the stock has a unimodal arrival. When an observation curve is visually between a cluster of predictions, then the stock was represented uniformly across the run at the site. Stock separation occurs at BON and is based on the prior year’s arrival timing at the dams



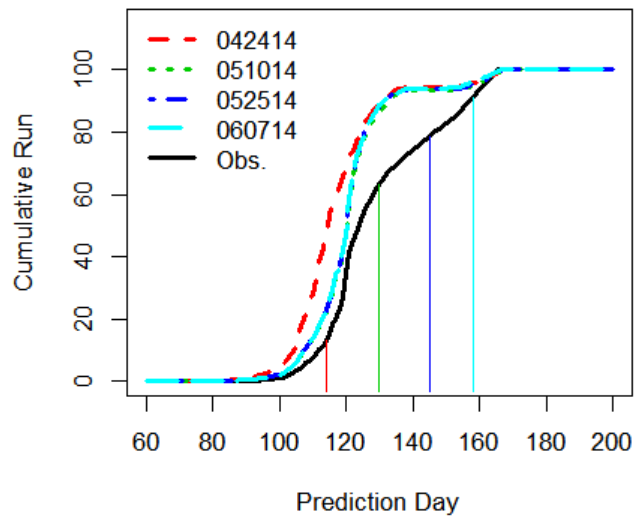
**SnakeSpring chinook at IHR**



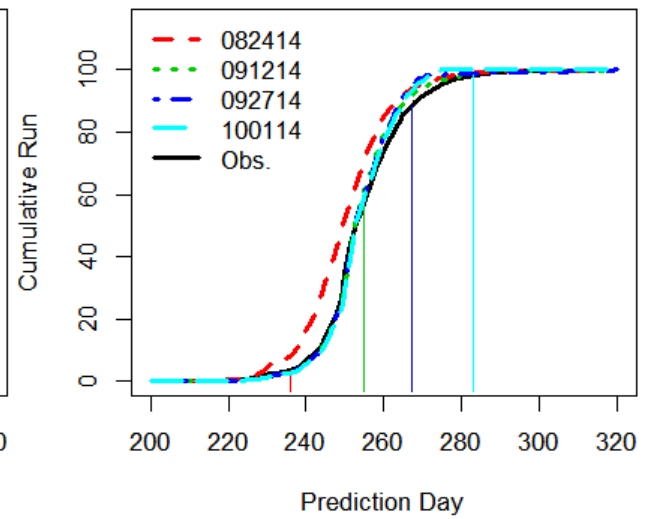
**SnakeSpring chinook at LWG**



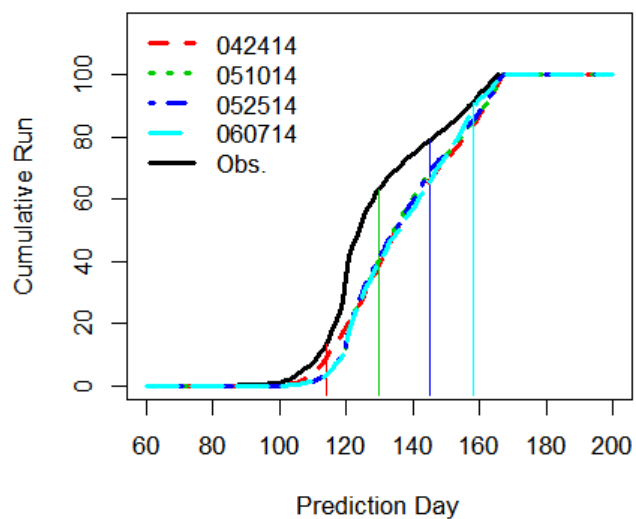
**LColSpring chinook at BON**



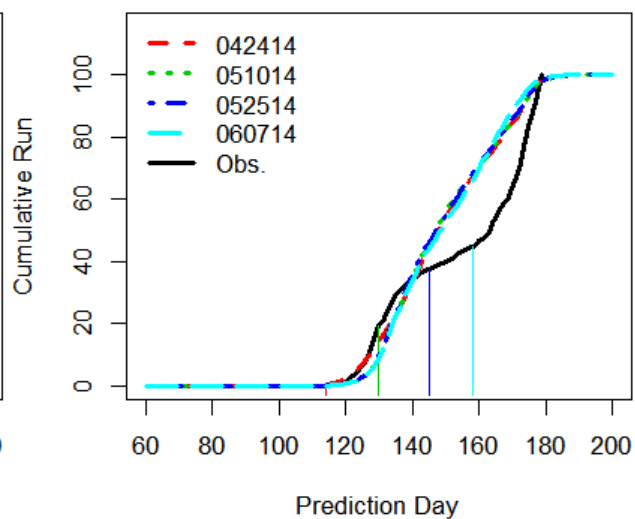
**LColFall chinook at BON**



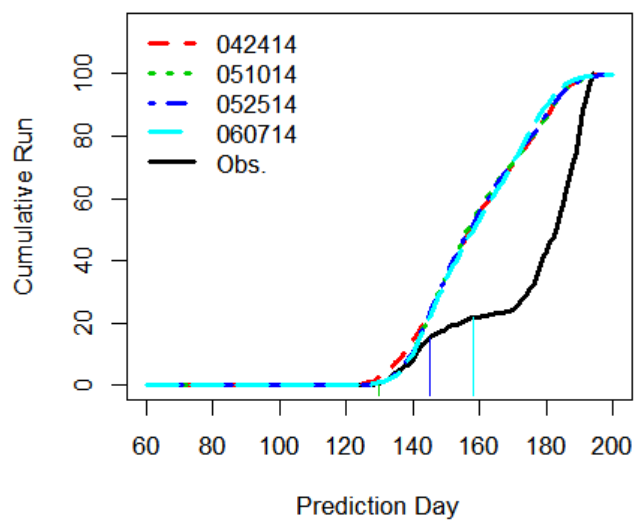
**UColSpring chinook at BON**



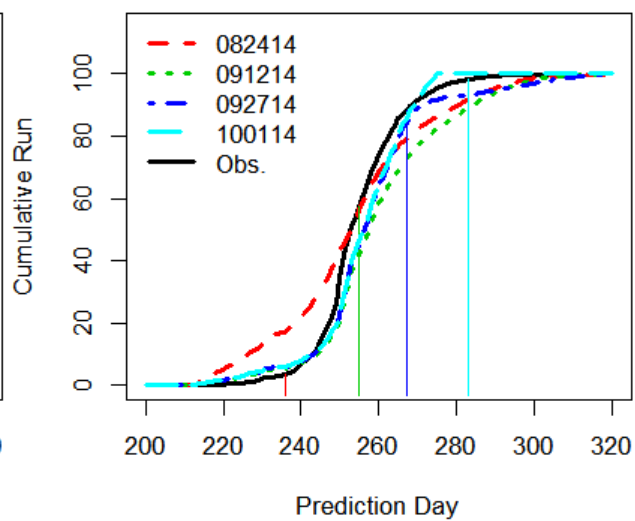
**UColSpring chinook at PRD**



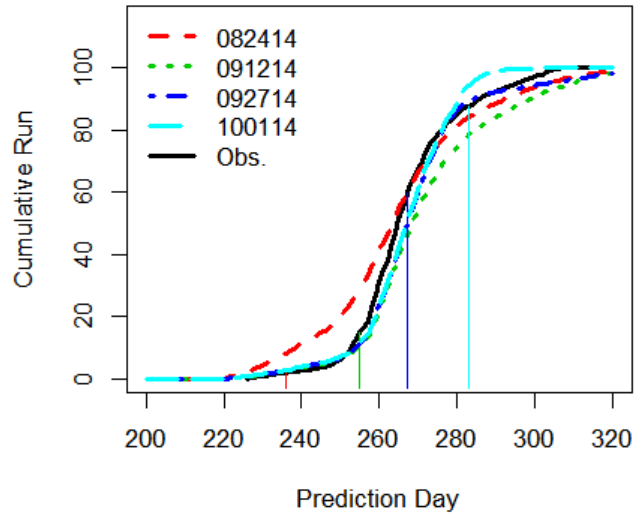
**UColSpring chinook at WEL**



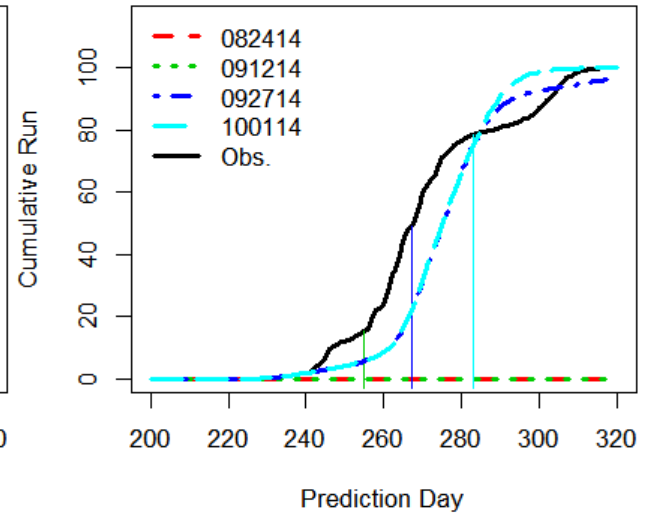
**UColFall chinook at BON**



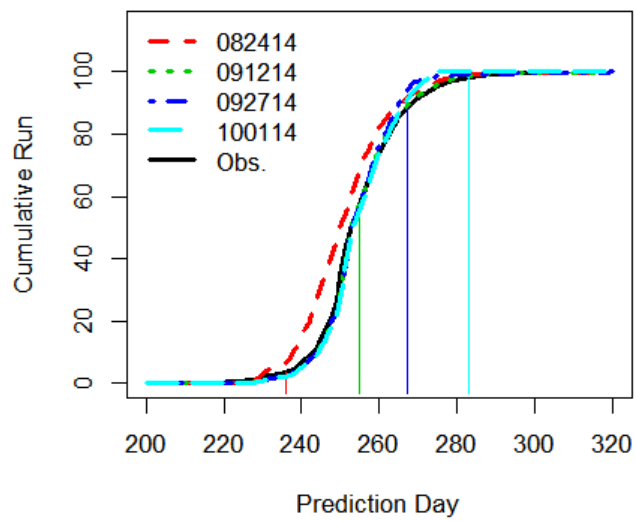
**UCoIFall chinook at PRD**



**UCoIFall chinook at WEL**



**YakimaFall chinook at BON**



**YakimaSpring chinook at BON**

